The effect of irrigation with chlorinated and bicarbonated waters of high salinity on the yields of the rose bush

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INTRODUCTION. — Salinity whether by its osmotic effects, or the toxic effects of the specific ions, frequently constitutes a limiting factor in the obtaining of high yields in the cultivation of the rose bush.

From a review of the relevant literature it appears that most of the authors consider the rose bush a plant sensitive or very sensitive to salinity (Asen, 1953; McCall, 1961; Boodeley, 1969). Bernstein (1964) attributes this sensitivity to the great facility with which the plant absorbs the Na⁺ and Cl⁻ ions. He includes the rose bush in the group of plants whose yields are noticeably reduced when they grow in soils with a saturation extract conductivity of between 2 and 4 mmhos/cm.

Furthermore, McCall (1961) notes a retarded development and serious salinity symptoms in rose bushes when the EC of the extract soil water (1:2) is between 1 and 1.5 mmhos/cm. The Laboratorio Agrinca (Spanish Levant) gives an EC of the saturated extract of 1.7 to 2.5 mmhos/cm as suitable levels for this plant (López Melida, 1981). Moulinier (1975) finds retarded development and radicular absorption when the concentration of soluble salt in the soils (except in the case of sulphates) exceeds 0.2%. The Floriculture Soil Testing Laboratory at Cornell, and also the Pennsylvania State University (extract solution 1:2) recommend a content of total salts below 150 ppm.

One of the principal causes of the salinization of cultivated soils is the use of poor-quality irrigation water: this is particularly true of the cultivation of roses in the island of Tenerife. The waters used for the irrigation of these plants in the island belong in most cases to the classes Cl and Ca which correspond, according to the system of the Salinity Laboratory of the USA (1973), to a high salinity and the danger of a low or medium sodium content. As regards the anionic composition, we should point out that the Cl⁻ may reach values of up to 15 meq/l in well water, while the CO₃²⁻ may be present in concentrations of up to 16 meq/l. The concentrations of these anions exceed, on many occasions, those indicated as dangerous for this plant by various authors.

The Cl⁻ has been much studied because of its unfavourable effect on the quality of the flowers. In fact, the tolerance limits of the rose bush are generally related to the increase of the Cl⁻ in the soil solution. Thus, Hughes (1977) finds that the total production in the roses «Forever Yours» is reduced by 10% when 8 meq/l of ClNa is added to the nutritive solution.

Yaron (1969) finds that in the variety «Baccara» on R. Chinensis the yield decreases when chlorinated water with an EC of 2,000 µmhos/cm is used, while water of the same conductivity in which the NO₃⁻ predominate has no appreciable effect on production. Ishida (1978) using water with 250 ppm of Cl⁻ on the variety «Sunlight» on R. Multiflora notes marginal burns on the old leaves and a reduction in the number and height of the flowering stems. The same author in a later study (1979) finds that damage to the plants is produced with 500 ppm of Cl⁻ in sand, and 1,000 ppm or higher in soil.

Bernstein (1972) finds that the growth of the rose bush decreases by 25% or more when the basis of the salinity is ClNa and SO₄Na with an EC of between 2.100 and 3.100 µmhos/cm. Yaron (1969) indicates 3 meq/l as a tolerable Cl⁻ level in the water, while with 10 meq/l shortening of the stems occurs, and with 25 meq/l serious burns appear in the foliage.

As regards the CO₃²⁻, Hughes (1975, 1976, 1977, 1978) finds in plants of «Forever Yours», irrigated with waters of various salinities containing variable concentrations of this anion, that, above 2 meq/l, production and quality are reduced due to chlorosis, malformation of the shoots, delayed flowering, shortening of the stems and reduction in fresh weight.

Sadassivalah (1970) notes that the addition of CO₃²⁻ to irrigation water exercises a depressive effect on the production, whereas the presence of ClNa up to 6 meq/l has little effect on development.
The Na⁺ ion is generally considered as toxic as the Cl⁻, although it is difficult to determine the specific effects of either ion separately, since they are usually associated in natural waters. This cation can reach high concentrations in the irrigation water used for roses in Teneriffe, especially well water (up to 12 meq/l). On this point we should mention that Hughes (1977) shows that rose production is considerably reduced when irrigation water contains 8 meq/l of Na⁺.

In a study which we carried out on the rose-growing soils of the island we showed that, despite high EC values of the saturated extract (up to 5 μhos/cm, 25°C) and the concentrations of Cl⁻, CO₃H⁻ and Na⁺, the plants do not exhibit apparent toxic symptoms. With the aim of quantifying the possible effects of total salinity and the Na⁺, Cl⁻ and CO₃H⁻ ions in irrigation water on the yields of the rose bush, we carried out the present study.

**Material and Methods.** — A greenhouse trial was carried out consisting of cultivating, in 10 kg pots, roses of the variety «Sonia» on Canina Inermis which were irrigated with waters of high bicarbonate and chloride concentration. The soil characteristics were as follows:

<table>
<thead>
<tr>
<th>pH</th>
<th>O.M %</th>
<th>P₂O₅ (ppm)</th>
<th>C.I.C</th>
<th>Exchangeable Cations (meq/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>2.30</td>
<td>24</td>
<td>22.60</td>
<td>4.9 Ca⁺⁺ Mg⁺⁺ Na⁺ K⁺</td>
</tr>
</tbody>
</table>

In addition, the mechanical analysis gave the following results: 35.90% clay, 27.50% silt and 36.6% sand which represents a loamy-sandy texture.

The soil was mixed with peat in the proportion 3:1. Before sowing, 500 mg of Mg, Ca (OH)₂ at the rate of 3.5 meq/100 g of Mg; Ca (OH)₂ at the rate of 4.6 meq/100 g of Ca; 1.5 meq/100 g of K in the form of DO₂K and 250 ppm of P₂O₅ were added to the soil.

The transplanting of the roses to the pots was carried out in July. The amount of irrigation water used was fixed at water holding capacity in each pot, and the frequency was determined by tensiometers.

Nitrogenous fertilizer at the rate of 3.5 g per pot was applied weekly in the form of SO₂(NH₄)₂; micronutrients were applied monthly to the plants.

The treatments used consisted of 3 irrigation waters whose chemical composition appears in Table No. 1.

The control was irrigated with water of medium salinity and low alkalinity (CS, according to the classification of the Salinity Laboratory of USA).

The solutions (1) and (2) were obtained from this water by the addition of CO₂HNa and ClNa respectively. The CO₂H⁻ and Cl⁻ of these solutions are similar to the poor-quality bicarbonate and chlorinated waters of the Island of Teneriffe (Fernández Caldas, 1974).

The treatments consisted of 12 repetitions each corresponding to the same number of plants distributed totally at random.

Twelve months after the start of the treatments foliar and soil samples were taken for analysis.

The criterion used for the taking of leaf samples was as follows: the first two leaves of 5 leaves, on shoots where the bud showed from 1 to 3 segus open, were chosen. This technique has been applied by us in previous studies on the nutrition of the rose bush.

The determinations of pH were carried out in the saturated extract. The % of O.M. was determined by the dry-combustion procedure. The available P₂O₅ was determined by the Olsen method. The exchangeable cations Na⁺ and K⁺ were determined in the extract of AcNH₄ by flame photometry, and the Ca⁺⁺ and Mg⁺⁺ by atomic absorption spectrophotometry.

The electrical conductivity, and also the soluble cations and anions were determined in the extraction extract.

The foliar analysis was carried out by dry-ash method, the Cl⁻ in the aqueous extract of the ash being determined by titration with NO₃Ag.

The flower production of each plant was classified according to the following criteria: Extra (stem longer than 80 cm); first and second (between 50 and 80 cm); third (less than 50 cm).

**Results and Discussion.** — Table No. 2 sets out the determinations of salinity and fertility carried out in the soils at the end of the trial, and also the productions for the three treatments under study. It will be noted that the EC of the saturated extract increases to a value of 2.252 μhos/cm in the case of the treatment with CO₂H⁻, and of 3.222 μhos/cm in that of Cl⁻.

The concentrations of soluble and exchangeable sodium increase considerably in the soils corresponding to the two treatments when compared with those of the control, although they are higher in the extract corresponding to the chlorinated water. As regards the anions, a clear rise in the Cl⁻ concentration in the extract corresponding to...
the chlorinated waters will be noted, whereas the concentration of the bicarbonate anions does not increase significantly.

Table 2. - Analysis of soils, and quantitative and qualitative yields of the rose bush.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>pH</th>
<th>O.M. %</th>
<th>P.O. ppm</th>
<th>E.C. 25°C mhos/cm</th>
<th>Soluble ca. Na⁺ K⁺ Ca⁺⁺ Mg⁺⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4.6</td>
<td>2.29</td>
<td>38</td>
<td>1383</td>
<td>6.88 1.15 4.00 2.27</td>
</tr>
<tr>
<td>Solution 1</td>
<td>5.4</td>
<td>2.15</td>
<td>50</td>
<td>2252</td>
<td>17.10 0.56 2.00 2.13</td>
</tr>
<tr>
<td>Solution 2</td>
<td>4.5</td>
<td>2.23</td>
<td>43</td>
<td>3222</td>
<td>21.74 1.02 2.53 2.33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soluble anions</th>
<th>Exchangeable Cations (meq/100 g)</th>
<th>Number of flowers/plan.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₃²⁻</td>
<td>Ca²⁺</td>
<td>Mg⁺⁺</td>
</tr>
</tbody>
</table>
| 0.00 | 1.47 | 2.80 | 1.87 | 3.48 | 0.97 | 11.00 (27.36)
| 0.00 | 2.07 | 2.77 | 3.22 | 3.93 | 1.23 | 6.40 (22.10)
| 0.00 | 0.97 | 1.51 | 6.16 | 2.55 | 0.70 | 5.11 (20.78)

In the case of the treatment with chlorinated water (solution 2) the unfavorable effect on production could be due to the Cl⁻ or the Na⁺ ion, or the combined effect of both. As, moreover, the concentrations of these ions in the soil are greater than those of the bicarbonate it is impossible to compare the effect of both anions as far as quality is concerned.

Furthermore, the foliar Cl⁻ content of the control plants and that of the plants irrigated with chlorinated water differ fairly widely, the former reaching values of 500 ppm of Cl⁻ and the latter up to 1,100 ppm of Cl⁻. Nevertheless, the visual symptoms typical of these cases - chlorosis and scorching of the tips of the foliage - are not noted in either treatment. This fact is of great interest in the commercial cultivation of the variety SINTA, since the grower can see no signs in the plant, and yet production may be seriously affected.


López M., M., Cultivo del rosal en sistemas, Murcia, 1981.


BIBLIOGRAPHY
RESUMEN. — Dado que la aplicación de aguas de riego de mala calidad es, con frecuencia, causa de la salinización de los suelos dedicados al cultivo de rosas en Tenerife, hemos realizado una experiencia de riego con dos aguas de alta salinidad y con concentraciones de 15.70 meq/l de Cl⁻ y 13.60 meq/l de CO₃²⁻, respectivamente. Sobre el cultivar «Sonia», ambos tipos de aguas ocasionaron una reducción significativa de los rendimientos, que fue mayor en el tratamiento con agua clorurada. La calidad de la flor (expresada como porcentaje de flores extra) disminuye considerablemente en las plantas tratadas con agua bicarbonatada, y llega a reducirse en un 50% con respecto al testigo, en el caso de las rosas regadas con agua clorurada. En ninguno de los casos se apreciaron síntomas visuales de toxicidad por sales.

RIASSUNTO. — L'applicazione di acqua d'irrigazione di qualità deficiente è, con frequenza, causa delle salinità dei suoli coltivati a rosso, a Tenerife.

E' stata realizzata un'esperienza d'irrigazione con due acque di elevata salinità e con tenori di 15,70 meq/l di Cl⁻ e 13,60 meq/l di HCO₃⁻. Quanto alla varietà «Sonia», le due acque hanno prodotto una riduzione significativa dei rendimenti, più elevato nel caso dell'acqua clorurata. La qualità del fiore (espressa come % di fiori extra), diminuisce considerevolmente nelle piante irrigate con acqua bicarbonatata, e diminuisce del 50%, rispetto al controllo, nel caso delle piante irrigate con l'acqua clorurata. In nessun caso sono stati apprezzati sintomi visivi di tossicità da sali.

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